Comparison of Averaging-Type and Computational Homogenization Methods in Nonlinear Magnetodynamic Problems

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The ferromagnetic cores of electromagnetic AC devices are often laminated in order to reduce the eddy current losses due to the time-varying flux. Nevertheless, the eddy current effects in laminated iron cores may considerably alter the overall behaviour and performance of electromagnetic devices. This is the case in e.g. power electronic applications where working frequencies and harmonic distorsion are constantly increasing. Therefore, they should be accounted for in the early stages of the design. Finely discretizing each separate lamination in standard finite element models is prohibitively expensive in terms of memory requirements and computation time. Alternative methods are thus indispensable. Many techniques have been successfully applied for dealing with lamination stacks in finite-element models: nonconducting and homogeneous stacked core with *a posteriori* loss estimation, anisotropic surrogate material laws, embedded lower dimensional models, multiscale computational homogenization techniques, ...

In this paper, we will compare the performance and validity range of an averaging-type homogenization technique with those of a multiscale computational homogenization technique. The averaging-type homogenization technique (J. Gyselinck *et al*, "A nonlinear time-domain homogenization technique for laminated iron cores in 3-D finite-element models," IEEE Trans. Magn., vol. 42, no. 4, pp. 763–766, 2006) is based on a polynomial expansion of the variation of the induction throughout the thickness of a lamination and further embedded in a magnetodynamic FE formulation. The multiscale approach presented in (I. Niyonzima *et al*, "Computational Homogenization for Laminated Ferromagnetic Cores in Magnetodynamics", in Proc. of the 15th Biennal Conference on Electromagnetic Field Computation, 2012) is built up within the heterogeneous multiscale method framework. It couples: 1) a macroscale problem that captures the slow variations of the overall solution; 2) many microscale problems that allow to determine the macroscale constitutive law. Particular attention will be paid to local data.